REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*
12/31/2010

2. REPORT TYPE
Annual

3. DATES COVERED *(From - To)*
2009.10.1 -- 2010.9.30

4. TITLE AND SUBTITLE
A Wireless Network Testbed for Stochastic Network Optimization

5a. CONTRACT NUMBER
N00014-09-1-0951

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Chiang, Mung

5d. PROJECT NUMBER
10PR07104-00

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Princeton University
Engineering Quadrangle
Olden Street
Princeton, NJ 08544

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
875 North Randolph Street
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
This is an infrastructure development project for a new laboratory at Princeton, now called the Princeton EDGE Lab. Latest updates can be found at http://scenic.princeton.edu. The Princeton EDGE Lab has experimental facilities to study edge networking, wireless as well as wireline. It crosses the boundary between theory and systems in the networking research community. It leverages the lessons and data accumulated through realistic experiments to validate the predictions of theory, falsify the assumptions behind theory, sharpen the characterizations that are loose in theory, and inspire new question formulations in theory. It builds systems designed by proven theorems and proves theories about built-out systems. It is more realistic (end-to-end) and comprehensive than all other university facilities in the area of edge networking, and more configurable and research-enabling than all other industry facilities. It consists of a wide range of equipments offering programmability at various layers and visibility at various temporal and spatial scales.

15. SUBJECT TERMS
Experiment, Facilities, Networking, Wireless Communications

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
			None		Mung Chiang
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPONE NUMBER (***Include area code***)
					609-258-5071

N00014-09-1-0951 DURIP Project Report
December 2010

1. Project Participants at Princeton University

1.1 Principal Investigator

Mung Chiang
Associate Professor of Electrical Engineering
Princeton University

1.2 Post-doctoral researchers

Dr. Sangtae Ha

1.3 Collaborators

Qualcomm
Microsoft
Nokia-Siemens
Google
AT&T
Telcordia

2. Activities and Findings

2.1 Major Research and Education Activities

This is an equipment grant for a new laboratory at Princeton, now called the Princeton EDGE Lab. Latest updates can be found at http://scenic.princeton.edu

The Princeton EDGE Lab has experimental facilities to study edge networking, wireless as well as wireline. It crosses the boundary between theory and systems in the networking research community. It leverages the lessons and data accumulated through realistic experiments to validate the predictions of theory, falsify the assumptions behind theory, sharpen the characterizations that are loose in theory, and inspire new question formulations in theory.

It builds systems designed by proven theorems and proves theories about built-out systems. It is more realistic (end-to-end) and comprehensive than all other university facilities in the area of edge networking, and more configurable and research-enabling than all other industry facilities.

It consists of a wide range of equipments offering programmability at various layers and visibility at various temporal and spatial scales. The list of equipments now include:

- WARP software defined radios (8 of them)
- Packet Storm WAN emulator
- Qualcomm 3G cellular emulator
- HP ProCurve software defined switches (2 of them)
- Allot Deep Packet Inspector
- Power Distribution Unit and portable power meter (for energy measurment)
- Digital oscilloscope
- Spectrum analyzer
- Signal generator
- Configurable set-top box
- HP servers (10 of them)
- WiFi access points
- iPad, iPhone, Android and other end user mobile devices
- Laptops for peer-to-peer experiments
- Uninterrupted power supply
- Configurable femto-cells
- Configurable 10G EPON

2.2 Major Findings

Over the past year, we have built the Princeton EDGE Lab from scratch, starting from an old, empty room, to a fully integrated environment where VLAN configurations even allow one to remotely change logical topologies.

Multiple research efforts have started to benefit from the EDGE Lab, including wireless scheduling, interference management, content aware networking, and stochastic network optimization, which are of particular interest to DoD applications.

2.3 Training and Development

This lab provides a truly unique environment for postdocs, grad students, and undergrads to get trained across the traditional boundary between theory and systems sides of networking. Already all my postdocs and graduate students are using the platform, and six undergrad students are doing independent work in the lab.

2.4 Outreach Activities

The first annual Open House will be arranged during April 2011. The Princeton EDGE Lab Seminar series started in June 2010.

The EDGE Lab is also supported by 6 industrial partners listed above.

3. Publications

Since this is a 1-year equipment grant, the main focus is on equipment purchase, debugging, and integration. Nonetheless, the following publications in 2010-2011 already benefited from this grant:

1. J. Liu, Y. Yi, A. Proutiere, M. Chiang, and H. V. Poor, "Convergence and tradeoff of utility-optimal CSMA", *Wiley Journal of Wireless Communications and Mobile Computing, Special Issue on Advances in Wireless Communications and Networking*, vol. 10, no. 1, pp. 115-128, January 2010.

2. M. Chen, S. Liu, S. Sengputa, M. Chiang, J. Li, and P. A. Chou, "P2P streaming capacity under node degree bound", *Proc. IEEE ICDCS*, Genoa, Italy, June 2010.

3. A. Proutiere, Y. Yi, T. Lan, and M. Chiang, "Resource allocation over network dynamics without timescale separation", *Proc. IEEE INFOCOM*, San Diego, CA, March 2010.

4. L. Qian, Y. J. Zhang, and M. Chiang, "Globally optimal distributed power control for nonconcave utility maximization", Proc. IEEE GLOBECOM, Miami, FL, December 2010.

5. W. Ouyang, A. K. Wong, M. Chiang, K. Woo, Y. Zhang, H. Kim, and X. Xiao, "Energy efficient assisted GPS measurement and path reconstruction for people tracking", *Proc. IEEE GLOBECOM*, Miami, FL, December 2010.

6. W. Jiang, S. H. G. Chan, M. Chiang, J. Rexford, K. F. S. Wong, and C. H. P. Yuen, "Proxy-P2P streaming under the microscope: Fine grain measurement of a configurable platform", *Proc. IEEE ICCCN*, Zurich, Switzerland, August 2010.

7. J. Lee, J. Lee, Y. Yi, S. Chong, A. Proutiere, and M. Chiang, "Implementing utility optimal CSMA", (Invited Paper), *Proc. 47th Allerton Conference*, September 2009.

8. B. Nardelli, J. Lee, K. Lee, Y. Yi, S. Chong, E. Knightly, and M. Chiang, "Experiment evaluation of optimal CSMA", *Proc. IEEE INFOCOM*, Shanghai, China, April 2011.

4. Contributions

4.1 To the Principal Discipline and Other Disciplines

Theory in wireless networking is "inalienable" since it offers explanatory, rather than descriptive models and top-down design with predictive power. Theory is also "incomplete" given its sensitivity to the mathematical crystallization and the need to make a difference in live networks. As an edge between theory and practice of networking, the Princeton EDGE Lab builds systems designed by proven theorems, and proves theorems about deployed systems. It is capable of enabling

A. Bigger overlap between the two (eg, develop the theory for tight bounds on convergence rate, transient behavior characterization rather than equilibrium behavior, impact of control parameter granularity and feedback noise, remove timescale separation assumptions, etc.)

B. New theory questions (eg, proper accounting of computational and communication overhead, or simplicity-driven optimization: insist on zero overhead rather than optimality proof and then tightly bound suboptimality gap and its impact on user performance)

C. Theory-inspired deployment (e.g., transfer some of the theory inspired algorithms to commercial/DoD adoption and large scale operations serving real customers, and turn some of the challenges in that process to inspire new theory).

4.2 To Development of Human Resource

Very few research groups around the world in the area of networking provide an environment that trains both in theory and in systems at the same time. The Princeton EDGE Lab carries out the entire loop: from modeling to analysis to design to system-building to data collection and back to modeling. This will significantly enrich the Ph.D. program including those interested in DoD applications, while providing an exciting range of opportunities for undergrad students interested in networking research experiences.